WARD'S

Encounters of the Worst Kind:

Water Pollutants and a Living Organism

Teacher's Notes

750-3500

ENCOUNTERS OF THE WORST KIND: WATER POLLUTANTS AND A LIVING ORGANISM

BACKGROUND

Chemicals that enter the water come from a myriad of sources. To date, regulatory agencies charged with the control of such pollutants have concentrated their efforts on "point sources"—easily identified by discharge pipes or other outflow devices. Permits are granted that limit the permissible level for each pollutant and monitoring is done periodically to ascertain if the permit limitations are being followed. Non-point sources such as run-off from cropland, roads, and watersheds are being given more attention recently; area Soil Conservation Services personnel administer several programs aimed at decreasing input of water pollutants from non-point sources.

Because of the phenomenon known as "biological magnification," water containing levels of pollutants so low that the water is deemed "potable"—or fit to drink—can still be a source of problems. For example, large, long-lived fish have been found to have a concentration of PCB that is ten million time greater than the water concentration of PCB. Two characteristics of the PCBs make them likely candidates for biological magnification. First, the PCBs are difficult for biological processes to degrade to harmless products; the bacteria and other organisms that usually accomplish these tasks lack the necessary enzymes to handle such man-made materials. Because they were never exposed to such chemicals before, they did not evolve the enzymatic capability to process these exotic substances. Second, the PCBs are fat-soluble so they concentrate in the fat tissue of an organism and are not flushed out with the water-soluble compounds. Thus, during an organism's lifetime, the fat tissue increases its concentration of the chemical and this concentrated chemical is passed onto the organisms in the next level of the food chain. As this continues up the food chain, the final consumer retains a remarkably high concentration of the chemical in its body fat. Thus water that is safe to drink can be the home to fish that greatly exceed levels for such fat-soluble compounds that are considered acceptable for human consumption. The FDA recently lowered the acceptable level of PCB's in commercial fish from 5 ppm to only 2 ppm (parts per million.)

Metallic ions may enter the circulatory system of a fish directly from the water by gill uptake. Active transport of necessary minerals from the water may simultaneously result in the absorption of toxic ions that mimic the required metallic ions.

Water pollutants frequently show the phenomenon of positive synergy; this occurs when two pollutants which have little effect when encountered alone, combine to multiply each other's effects on a living organism with dramatic results. Regulatory agencies must be aware of the positive synergy effects that may be shown by the water pollutants listed on the permits they issue to a discharger; they must consider the overall, combined effects of these chemicals or the organisms in the receiving waters will be in peril.

WHAT NEEDS TO BE DONE?

(1) Students need to become discriminating consumers and question the products available to them on the store shelves. Read the labels. Decide if they really want to buy and use certain products or are there safer alternatives? Will they be able to use all of a certain product for a specific task or will they be "stuck" with a toxic chemical and find that they have no way of disposing of it safely?

(2) Support legislation and funding proposals for the regulation of point and non-point sources of water pollutants. Talk to the personnel of the nearby water pollution control agency, the Soil Conservation Service, municipal water works, etc.

(3) Support legislation that limits the manufacture of toxic chemicals and strictly controls those for which there is no substitute. Invite a legislator for talk to the class about these efforts.

(4) Find out how local industries, hospitals, auto service centers, etc. dispose of their toxic materials. What efforts are they making to decrease the toxic substances which they produce?

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Procedure Notes

The six chemicals used in this kit are furnished in dropper containers that permit each student experiment to be accomplished with only one drop of the chemical. Thus the disposal of this tiny amount at the end of the experiment by flushing it down the sink is innocuous. The living organism used in the experiment, *Turbatrix aceti*, is harmless and has no parasitic tendencies.

The experiment consists of two parts. In the first part, the student assesses the effects of six different pollutants on the living organism. One drop of water, one drop of the chemical and one drop of the suspension of living organisms are used. This is done for each chemical in turn after the student has seen how the organism moves in a non-polluted, control situation. Bottle A contains the chemical which is most toxic to this organism. The organism will quickly lose its ability to travel in one direction. Instead, it will form coils with its long, cylindrical body and will die—an event marked by the lack of all motion and a straightening out of the organism—before the experiment's five-minute termination time. In contrast, the chemical in Bottle B will have little effect on the organism when used alone, making it useful for showing the phenomenon of positive synergy in the second part of the experiment. The remaining four chemicals will have intermediate effects on the organism, when compared to the effects of the chemicals in Bottles A and B.

In the second part of the experiment, the chemical in Bottle B is combined with each of the chemicals in Bottles C, D, E, and F in turn in order to look for the phenomenon of positive synergy. (In the first part of the experiment, one drop of water was used to keep the concentration for each chemical that same throughout the entire experiment.) Usually, the student finds evidence of some positive synergy in all four setups in the second part of the experiment.

The experiment concludes with a series of questions designed to reinforce the main objectives of the experiment.

Note: This kit provides enough material for a class of up to 24 students working in groups of 2.

Time Allotment:

50-60 minutes

Materials Provided in the Kits:

1	*Turbatrix aceti* culture		
12	Depression slides		
1	Bottle (A), Silver Nitrate	$AgNO_3$	0.25 M
1	Bottle (B), Mercury (II) Nitrate	$Hg(NO_3)_2$	0.01 M
1	Bottle (C), Nickel Nitrate	$Ni(NO_3)_2$	1 M
1	Bottle (D), Lead Nitrate	$Pb(NO_3)_2$	1 M
1	Bottle (E), Aluminum Nitrate	$Al(NO_3)_3$	1 M
1	Bottle (F), Copper (II) Nitrate	$Cu(NO_3)_2$	1 M
12	Sterile plastic pipets		
	Teacher's Notes		
	Student Study and Analysis Sheet (copymaster)		

Additional Materials Needed but Not Provided:

Distilled water
Compound or dissecting microscope

Personal Protective Equipment:

Goggles
Protective gloves

TEACHER'S NOTES

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ANALYSIS

Part I:

(1) Which of the six water pollutants tested was most toxic in regards to making the organism cease its directional motion?

Answer: Most students will find the silver ion has the greatest effect on this organism.

(2) Which solutions showed no toxic effects within five minutes when used alone?

Answer: The results reported by the students will vary because they will judge *when* the majority of the organisms have lost their ability to proceed in a unidirectional motion at different times. (A time limit of 5 minutes is imposed upon the experiment.)

Part II.

(3) Which solution showed the phenomenon of positive synergy to the greatest degree when it was combined with the solution in Bottle B?

Answer: Again, student results will vary but all students should observe the phenomenon of positive synergy in at least one of the four combinations of chemicals.

(4) Which other solutions also showed positive synergy to some degree with the solution in Bottle B?

Answer: See above. It is important only that the students witness an example of positive synergy occurring to the organism in order to appreciate its significance when water quality standards and limitations are set.

DISCUSSION

(1) Standards for various water pollutants are set to allow regulatory agencies, such as the E. P. A. or State Departments of Environmental Conservation, to issue permits to potential polluters in order to control the amounts of pollutants that can be released into a certain body of water. Ecologically, why is it more important to control such pollutants to prevent toxic effects on lower organisms, represented by the organism used in the exercise, instead of higher organisms such as birds or fish?

Answer: Two Reasons:

(1) Higher organisms are *dependent* on the lower organisms, represented by this invertebrate, in the food webs in nature.

(2) Invertebrates are usually more sensitive to toxic chemicals than higher organisms. Thus, it makes no sense to aim your protection standards on the more resistant members that are higher in the food web.

(2) How does the phenomenon of "biological magnification" complicate the setting of allowable levels of pollutants in an aquatic ecosystem?

Answer: Organisms in each trophic level of the food chain tend to concentrate toxics in their fats and oils. Many, many of these organisms are consumed by an organism in the next higher level, who continues to store and concentrate these toxics. If you want to protect your sport fish, birds, and top carnivores, you must restrict the amount of toxics you allow into the *water* of your aquatic ecosystems, knowing that biological magnification will occur.

(3) Why is it important to take the phenomenon of positive synergy into consideration when setting pollution standards for a specific body of water?

Answer: Since *combinations* of chemicals often *multiply* (not add) to each other's effects, you must *drastically* restrict the amount of each allowed into the water—if you suspect they will be there together.

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Notes:

For technical information or assistance, call Toll-free : 1-800-962-2660 or Fax : 1-716-334-6174

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